UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/04**

Paper 4 A2 Structured Questions **May/June 2009**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in Section A and **one** question from Section B.
Circle the number of the Section B question you have answered in the grid below.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
9 or 10	
Total	

This document consists of **19** printed pages, **4** lined pages and **1** blank page.

Section A

Answer **all** the questions.

For Examiner's Use

1 **(a)** The respiratory quotient (RQ) is used to show what substrates are being metabolised in respiration.

The RQ of a substrate may be calculated using the formula below:

$$RQ = \frac{\text{molecules of } CO_2 \text{ given out}}{\text{molecules of } O_2 \text{ taken in}}$$

When the unsaturated fatty acid linoleic acid is respired aerobically the equation is:

$$C_{18}H_{32}O_2 + 25O_2 \rightarrow \ldots\ldots\ldots CO_2 + 16H_2O + \text{energy}$$

(i) Calculate how many molecules of carbon dioxide are produced when one molecule of linoleic acid is respired aerobically.

answer ..... [1]

(ii) Calculate the RQ for linoleic acid.

answer ..... [1]

(b) Hummingbirds feed on nectar from flowers only during daylight hours. Nectar is rich in sugars.

Fig. 1.1 shows a hummingbird.

Fig. 1.1

A study of aerobic respiration in captive hummingbirds was carried out. The hummingbirds were allowed to feed freely and then made to fast for four hours in constant conditions. During this time their RQ values were calculated every 40 minutes.

For Examiner's Use

Fig. 1.2 shows the results from this study.

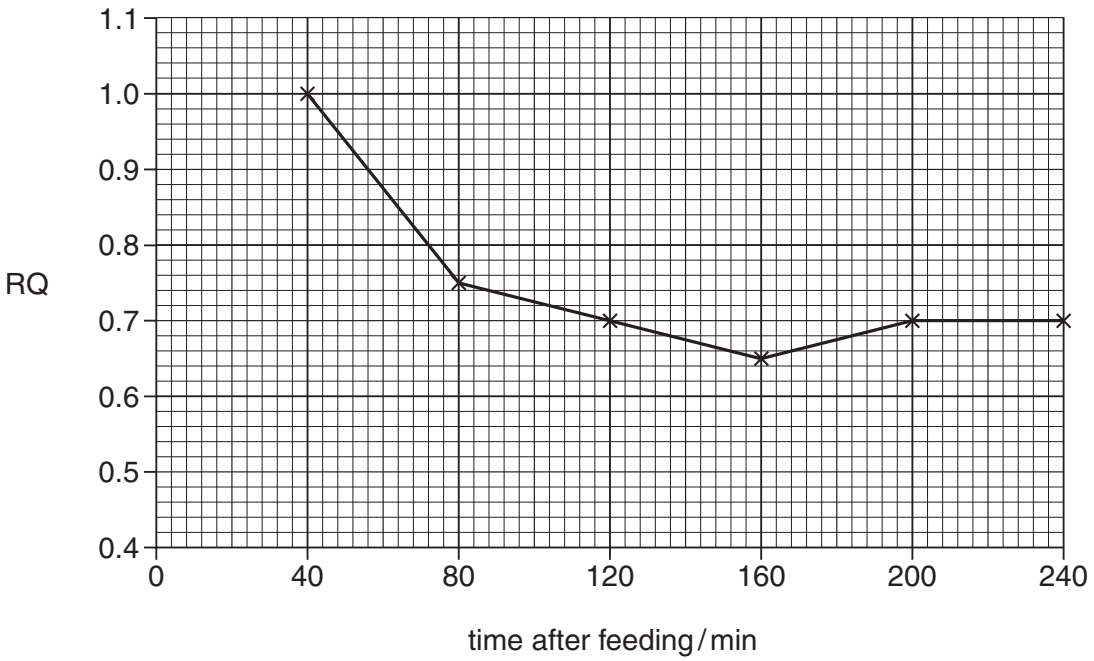

Fig. 1.2

Describe **and** explain the results shown in Fig. 1.2.

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..... [4]

(c) Hummingbirds regulate their body temperature whereas butterflies do not regulate their body temperature.

For Examiner's Use

Explain briefly the effect of an increase in temperature on the rate of respiration of a butterfly.

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..... [2]

[Total: 8]

For Examiner's Use

2 **(a)** The steroid hormones oestrogen and progesterone are secreted by the ovary.

State precisely the sites of secretion of each.

oestrogen .....

progesterone ..... [2]

(b) The most effective oral contraceptives for general use are the so-called combined oral contraceptives (COCs), which contain both oestrogen and progesterone.

Explain how COCs produce their effects.

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..... [4]

(c) Describe two **social** implications of the use of contraceptives.

1 .....

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2 .....

..... [2]

[Total: 8]

3 **(a)** The African elephant, *Loxodonta africana*, is a large herbivorous mammal which eats tree leaves. It has the longest gestation period of any land mammal and normally produces one offspring at a time. Its habitat is mainly savannah.

Suggest how human activities have caused the African elephant to become endangered.

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(b) The meerkat, *Suricata suricatta*, also lives in the savannah of southern Africa. It is a carnivorous mammal and feeds on insects, worms, snails and other invertebrates. It grows up to 30 cm in length and lives in large family groups in burrows.

Fig. 3.1 shows a meerkat.

Fig. 3.1

With reference to the information given, suggest why the meerkat is less likely than the elephant to become endangered.

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[Total: 6]

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Question 4 starts on page 8

4 **(a)** Fig. 4.1 shows a section through a maize fruit.

For Examiner's Use

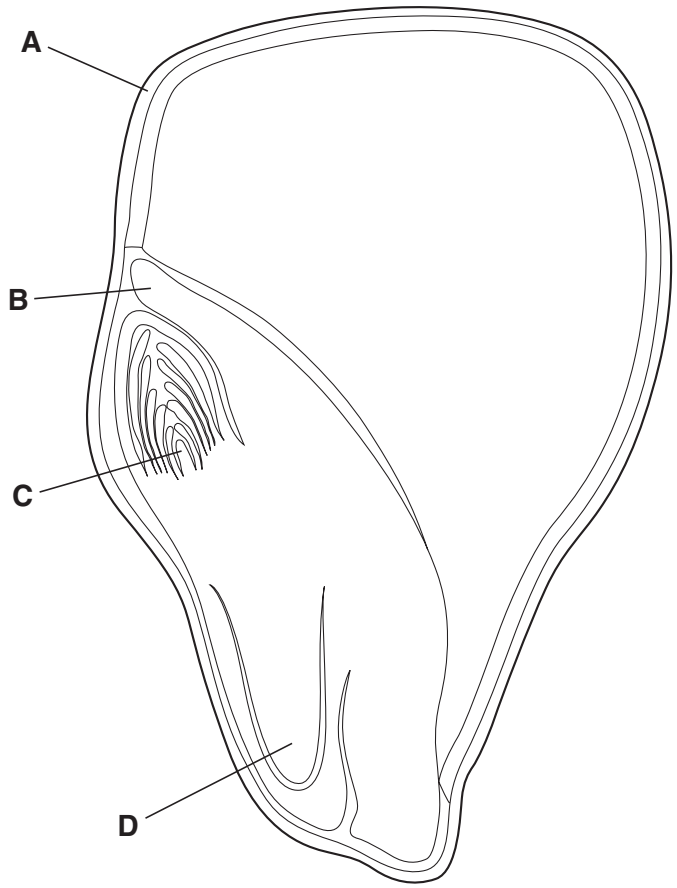

Fig. 4.1

(i) Name the parts labelled **A** to **D**.

A .....

B .....

C .....

D ..... [2]

(ii) Describe the function of the endosperm.

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..... [3]

(b) The corn earworm, is the larva of a moth *Helicoverpa zea*, that is a serious pest of maize. Insecticides containing pyrethrum have long been used to control this insect. These act by irreversibly inhibiting the enzyme acetylcholinesterase, which normally catalyses the hydrolysis of acetylcholine.

(i) Describe how an insecticide could irreversibly inhibit acetycholinesterase.

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..... [2]

(ii) Suggest the effects on synapses of this irreversible inhibition of acetylcholinesterase.

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..... [2]

(c) Some populations of *H. zea* have developed resistance to pyrethrum. This occurs as the result of a point mutation of the acetylcholinesterase gene. Many different such mutations have been identified in different populations.

Explain how a point mutation in the acetylcholinesterase gene could confer resistance to pyrethrum.

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(d) • A group of corn earworms was collected from a field where the farmer had reported resistance to insecticides containing pyrethrum.

• Another group was collected from a field where the insects showed no resistance (were susceptible).

• Some individuals from these two groups were crossed with each other to form a hybrid group.

Insects from each of the three groups were then exposed to a range of concentrations of pyrethrum. The percentage of the insects that were dead after 24 hours was recorded. The results are shown in Table 4.1.

Table 4.1

dose of insecticide / µg per group	% mortality of insects after 24 hours		
	resistant group	hybrid group	susceptible group
0	0	0	0
0.1	0	0	50
0.5	0	23	63
1.5	7	45	94
2.5	12	50	100
5.0	42	89	100
10.0	80	100	100
30.0	100	100	100

(i) With reference to Table 4.1, compare the effect of the insecticide on the resistant group and on the hybrid group.

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(ii) Assuming that resistance is conferred by a single point mutation in the gene for acetycholinesterase, suggest an explanation for the overall differences between all **three** groups of insects in Table 4.1.

For Examiner's Use

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[Total: 17]

For Examiner's Use

5 The fungus *Penicillium chrysogenum* is grown in fermenters on an industrial scale to produce penicillin, using a batch culture system.

(a) Explain why batch culture, rather than continuous culture, is used for the production of penicillin.

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(b) Temperature and pH are normally controlled in the fermenter. Temperature is kept constant, while pH is held at a value of 5.5 for the first stage of the fermentation and then raised to 6.8 and kept constant for the remainder of the fermentation period.

Fig. 5.1 shows how the pH and the concentration of penicillin in the culture change over time, when the pH is controlled and when the pH is not controlled.

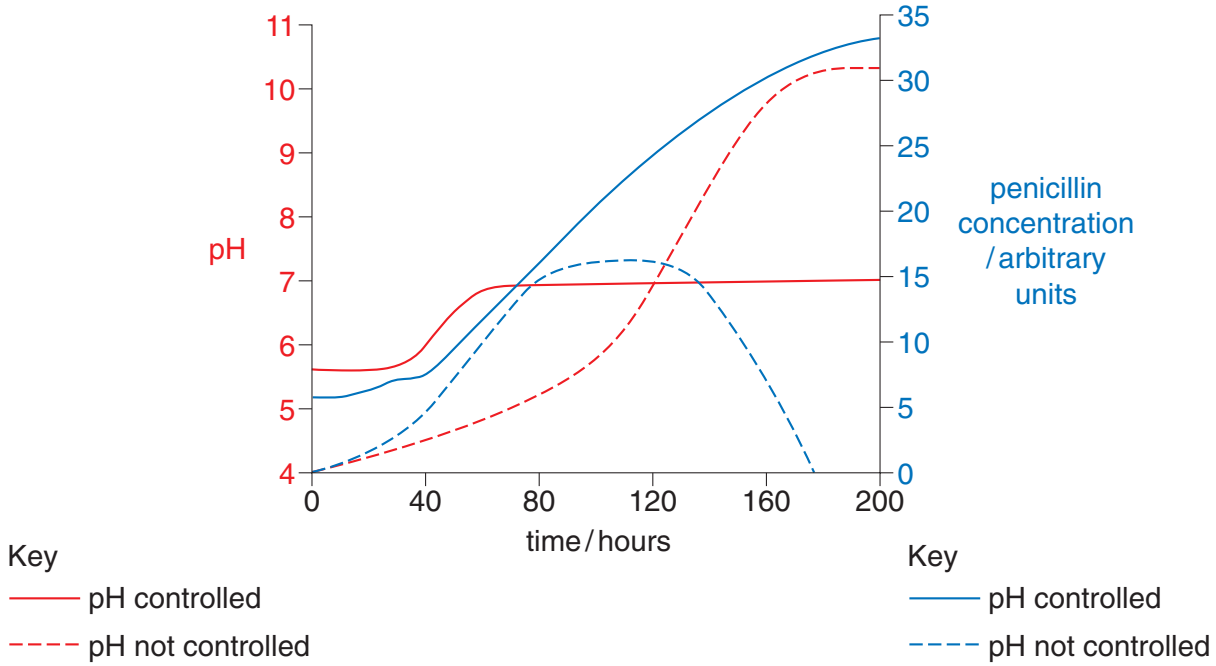

Fig. 5.1

With reference to Fig. 5.1, describe and explain the differences in the concentration of penicillin in the culture when the pH is controlled and when the pH is not controlled.

For Examiner's Use

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(c) Explain why penicillin affects bacteria but not viruses.

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[Total: 9]

[Turn over

For Examiner's Use

6 **(a)** Describe the role of insulin in the regulation of blood glucose concentration.

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..... [3]

(b) State two advantages of treating diabetes with insulin produced by gene technology.

1 .....

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2 .....

..... [2]

(c) One of the steps in the production of bacteria capable of producing human insulin is the insertion of the gene coding for human insulin into a plasmid vector.

Fig. 6.1 shows one of the artificial plasmids constructed to act as a vector.

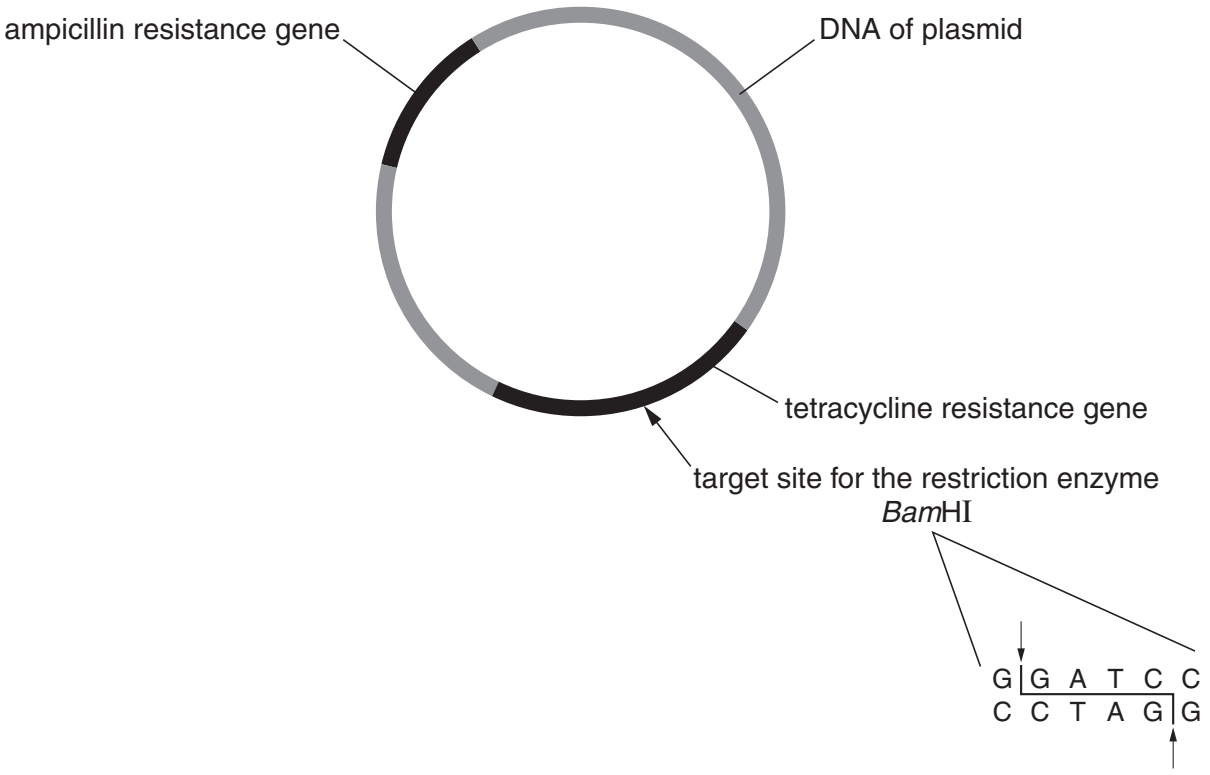

Fig. 6.1

(i) With reference to Fig. 6.1, explain the importance of the plasmid having a single target site for a particular restriction enzyme, such as *Bam*HI.

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..... [2]

(ii) The genes for ampicillin resistance and tetracycline resistance on the plasmid allow the genetic engineer to distinguish between bacteria that have taken up different circles of DNA.

Complete the table to show whether bacteria which have taken up each different circle of DNA are, or are not resistant to ampicillin, to tetracycline or to both. Show presence of resistance with a tick (✓) and absence of resistance with a cross (✗).

circle of DNA taken up by bacteria	bacteria resistant to ampicillin	bacteria resistant to tetracycline
unaltered plasmids		
recombinant plasmids that have taken up the wanted gene		
circles of the wanted gene		

[3]

(d) (i) Explain why genes for antibiotic resistance are now rarely used as markers in gene technology.

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(ii) Describe the use of **one** alternative marker gene that can be used instead of an antibiotic gene.

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[Total: 15]

7 **(a)** The inheritance of coat colour in horses is complex but all horses have one of two base colours, red (chestnut) or black. The base colour is controlled in a simple monohybrid way.

For Examiner's Use

- When chestnut stallions and mares are mated the foals are always chestnut.
- When black stallions are mated with black mares, either black or chestnut foals may be produced.

Draw a genetic diagram to show how two parents with black coat colour can produce a chestnut foal **and** the probability of such an event occurring.
Choose a letter symbol to represent coat colour.

[4]

(b) Five other genes can modify the base coat colour.

For Examiner's Use

One of these genes is the **C** gene. There are two alleles of this gene, **C** and $\mathbf{C^{CR}}$.

- **C** does not affect the base coat colour.
- $\mathbf{C^{CR}}$ may modify the base coat colour.
- If a chestnut horse has at least one $\mathbf{C^{CR}}$ allele its phenotype will be palomino, which is a light cream colour.
- If a black horse has at least one $\mathbf{C^{CR}}$ allele its effect will not be noticeable in the phenotype.

Complete the genetic diagram below.

parental genotype	**aaCC^{CR}**		**AaCC**	
parental phenotype	……		……	
gametes	……	……	……	……
offspring genotypes	……	……	……	……
offspring phenotypes	……	……	……	……

[4]

[Total: 8]

For Examiner's Use

8 **(a)** Fig. 8.1 shows a scanning electron micrograph of a section through a leaf of the Christmas rose, *Helleborus niger*.

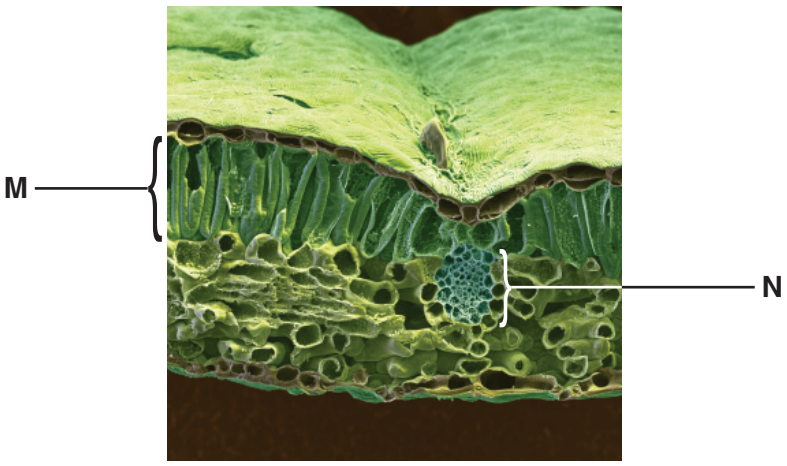

Fig. 8.1

Name **M** and **N**.

M .....

N ..... [2]

(b) Gases leave and enter the leaf through pores called stomata.

Describe **and** explain how a stoma is opened.

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..... [6]

(c) Fig. 8.2 outlines the main reactions in the light-dependent stage of photosynthesis.

For Examiner's Use

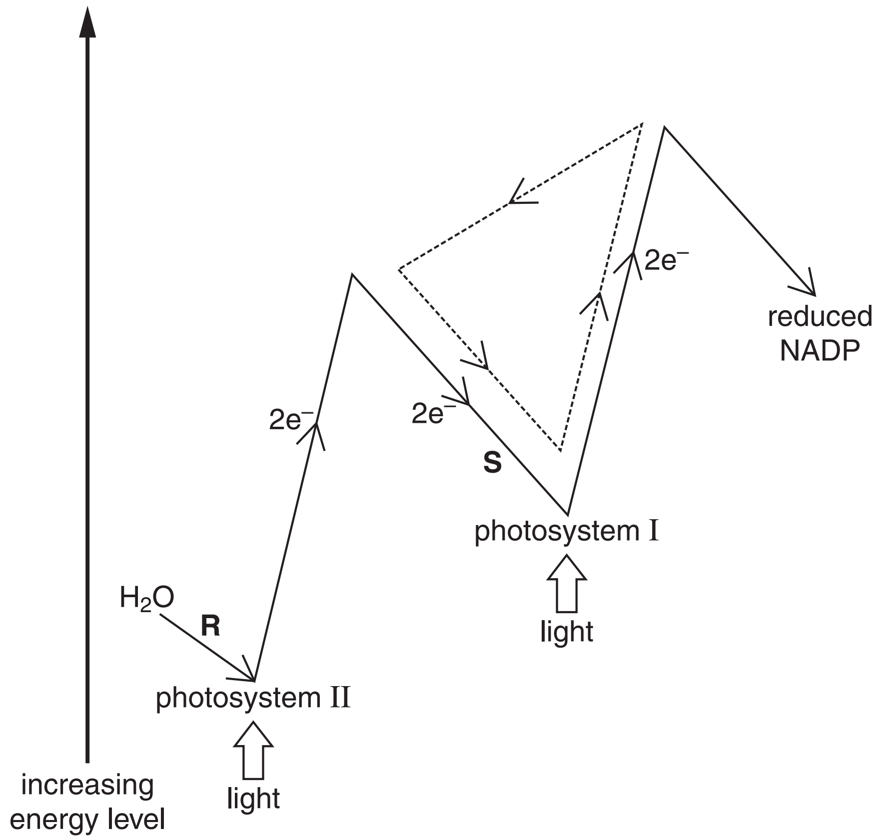

Fig. 8.2

(i) Name the process shown by the dotted arrows (-------->--------).

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(ii) Describe what happens to water at **R**.

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.... [2]

(iii) State the product formed as electrons flow along **S**.

.... [1]

(iv) Explain briefly the role of reduced NADP in the **light-independent stage**.

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.... [2]

[Total: 14]

Section B

For Examiner's Use

Answer **one** question.

9 **(a)** Explain how changes in the nucleotide sequence of DNA may affect the amino acid sequence in a protein. [7]

(b) Explain how natural selection may bring about evolution. [8]

[Total: 15]

10 **(a)** Describe the part played by the proximal convoluted tubules in the functioning of the kidneys. [8]

(b) Explain how the collecting ducts in the kidneys may reduce the loss of water from the body. [7]

[Total: 15]

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